

Natural Conditions Assessment for Low pH and Low Dissolved Oxygen, Mattox Creek and Tributaries in Westmoreland and King George Counties, Virginia



**Submitted by
Virginia Department of Environmental Quality**

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Executive Summary

This report presents the assessment of whether low pH and dissolved oxygen (DO) in Mattox Creek and tributaries are due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. Mattox Creek and tributaries, including five Unnamed Tributaries to Mattox Creek, Kings Mill Creek and Cow Swamp, located within Westmoreland and King George Counties, Virginia, are minor tributaries to the Potomac River. The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal Mattox Creek and tributaries is VAP-A31R. Mattox Creek and tributaries encompass approximately 31.62 rivermiles (National Hydrography Dataset (NHD)). Mattox Creek and tributaries were listed as impaired due to violations in water quality standards for pH and/or dissolved oxygen. This report addresses both the pH and dissolved oxygen impairments.

The total area of the Mattox Creek and tributaries watershed is approximately 28.5 square miles. The average annual rainfall is 41.18 inches. The watershed is approximately 18,263 acres in size and is predominately forested (56.8 percent). Agriculture encompasses 28.5 percent of the watershed, with 9.0 percent cropland and 19.5 percent pasture/hayland. Urban areas comprise approximately 3.2 percent of the land base, almost of which surrounds the tidal portion of Mattox Creek downstream of the low pH and DO area. Transitional/barren areas total 4.2 percent of the watershed. Wetlands and open water comprise 7.4 percent of the watershed.

The mainstem of Mattox Creek was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, and 2008 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, and 2008) due to violations of the State's water quality standard for pH. Mattox Creek and tributaries were then listed due to violations of the State's water quality standard for DO in the 2006 and 2008 305(b) / 303(d) Integrated Reports. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored 2 stations on non-tidal Mattox Creek and 3 stations on tributaries from April 1996 through July 2006. Of the 152 total pH data points recorded, 106 violated water quality standards for pH (70%), and 12 of 152 DO data points violated the water quality standards for DO concentration. However 5 of 23 DO violations were concentrated at one station 1AMAO010.27 (22%) and in the 2008 assessment 4 of 35 DO values at the original listing station 1AMAO007.46 (11%) violated the DO water quality standard. The original listing station for pH (1AMAO007.46) had a violation rate of 43 of 62 (69%), as shown in Figure E1. The station with the worst DO violation rate (1AMAO010.27) had a violation rate of 5 of 23 (22%), which is shown in Figure E2.

Figure E1. pH concentrations (station 1AMAO007.46), April 1996 through December 2006.

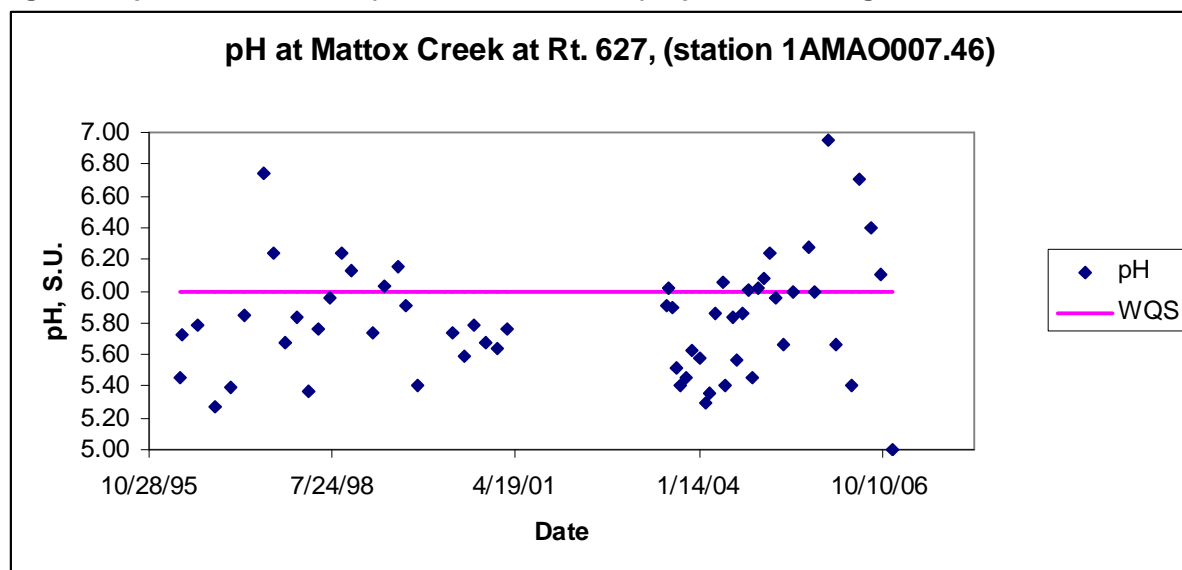
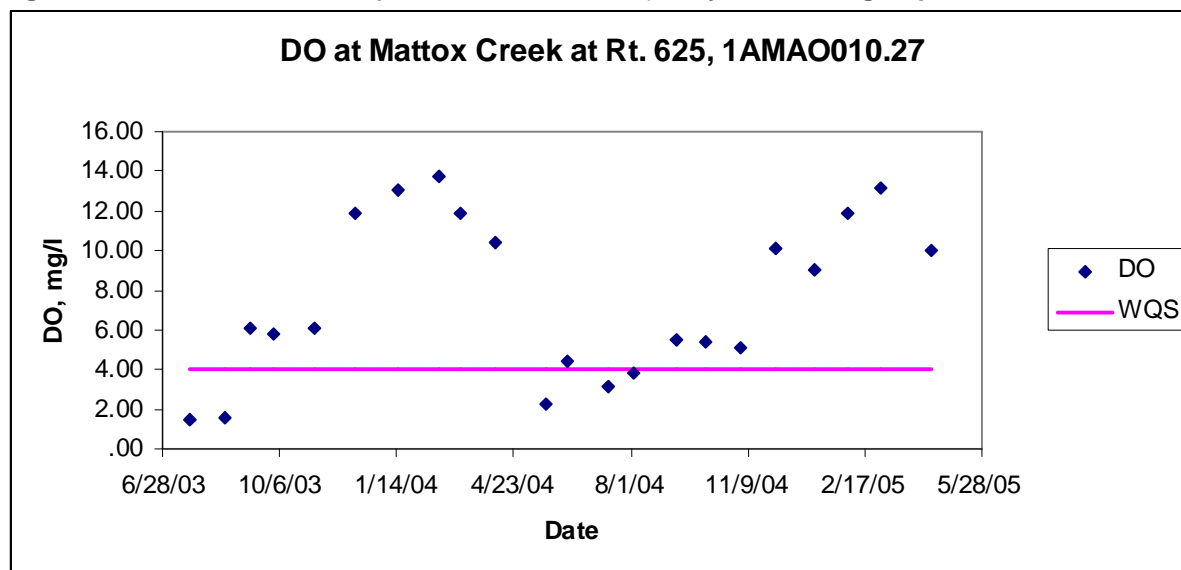


Figure E2. DO concentrations (station 1AMAO010.27), July 2003 through April 2005.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), “all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).”

As indicated above, the Mattox Creek tributaries must support all designated uses and meet all applicable criteria. If the waterbody violates the instantaneous DO water quality standard of 4.0 mg/l or pH values are less than 6.0 or greater than 9.0 in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from “Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia” (MapTech 2003).

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of swamps or wetlands. These conditions often also produce low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or low pH levels and for determining the likelihood of anthropogenic impacts is described below. DEQ staff use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

- Step 1. Determine slope and appearance (presence of wetlands).
- Step 2. Determine nutrient levels and compare with USGS background concentrations.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

No Mattox Creek and tributaries pH or DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

The slopes were determined for Mattox Creek and 4 tributaries. The low slope for these streams ranged from 0.19% to 0.42%, which was considered very low to low slope. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand, lower DO, result in production of weak organic acids, and lower pH as they decay. These are not considered anthropogenic impacts.

Mattox Creek and its tributaries exhibit low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

The Mattox Creek tributaries exhibit natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are 4 active permitted (1 VPDES; 1 VAG; 1 VAR; 1 VPA) Point Source facilities in the Mattox Creek and tributaries non-tidal watersheds (A31R). The VPDES permittee has a design flow, pH, DO and CBOD5 permit limits, which are shown in Table 7 along with permit exceedances. The facility exceeded its design flow 18 percent of the time with a maximum flow of 0.014 MGD (**0.16 gallons/sec**), however there were no pH permit exceedances, five DO exceedances with a minimum of 4.3 mg/l and 10 CBOD5 exceedances with the maximum of 35 mg/l. Walker Sand & Stone Westmoreland Pit (VAG840081) is a Non-metallic mineral mining permit and only has a pH limit, which it has not exceeded in 18 quarters. Shiloh Baptist Church is an industrial stormwater permit without limits for DO or pH. Northern Neck Farmers Market is a no discharge permit without DO or pH limits. These facilities are not expected to significantly impact DO or pH.

Urban areas compose approximately 3.2 percent of the land base, almost all of which occurs downstream of the impaired segment in the tidal portion of the watershed. This leaves an insignificant portion of the urban land use in the non-tidal portion of the watershed. Agriculture makes up approximately 28.5 percent of the watershed. The watershed is predominately forested (56.8 percent), with 3.3 percent wetlands and 4.1percent open water. Land use was not considered to have significantly impacted the swampwater conditions of Mattox Creek and its tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Mattox Creek and its tributaries located in waterbody identification code (WBID, Virginia Hydrologic Unit) A31R, a total of 31.62 rivermiles. If there is a 305(b)/303(d) assessment prior to the reclassification, Mattox Creek and these tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Mattox Creek tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Mattox Creek and tributaries including five Unnamed Tributaries to Mattox Creek, Kings Mill Creek and Cow Swamp, located within Westmoreland and King George Counties, Virginia, are minor tributaries to the Potomac River. Mattox Creek and tributaries encompass approximately 31.62 rivermiles. Staff determined rivermiles from the USGS National Hydrography Dataset using GIS. Mattox Creek and tributaries generally flow east from the headwaters near Weedons Fork, VA to the confluence with the Potomac River south of

Colonial Beach, VA. Mattox Creek is tidally influenced from approximately river mile 6.08 downstream to the confluence with the Potomac River. The watershed totals approximately 28.5 mi². There is no continuous flow gaging station on Mattox Creek.

2. Physical Settings

2.1. Listed Water Bodies

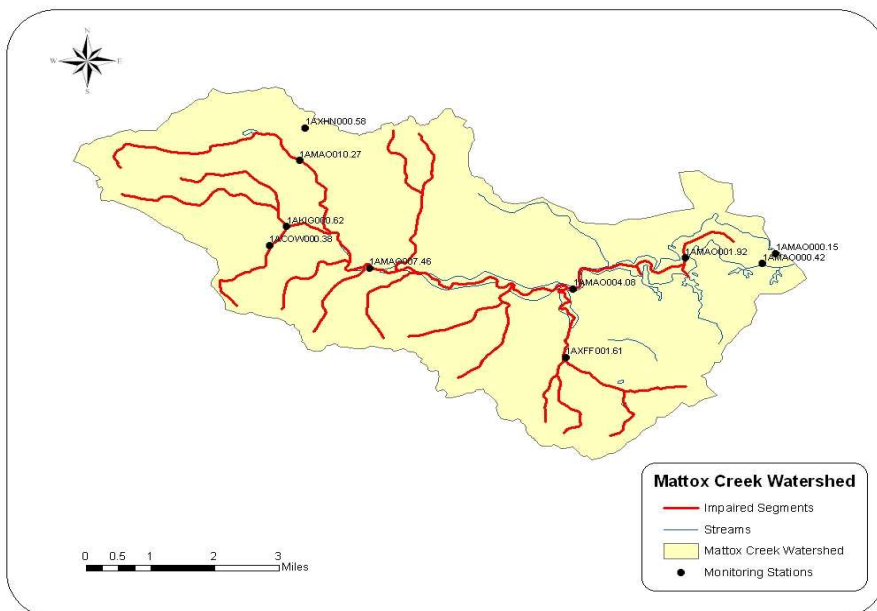
The mainstem of Mattox Creek was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, and 2008 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, and 2008) due to violations of the State's water quality standard for pH. Mattox Creek and tributaries were then listed due to violations of the State's water quality standard for DO in the 2006 and 2008 305(b) / 303(d) Integrated Reports. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL. The waterbody identification code (WBID, Virginia Hydrologic Unit) for the non-tidal Mattox Creek and tributaries is VAP-A31R.

2.2. Watershed

2.2.1. General Description

Mattox Creek and tributaries flow east from the headwaters at Weedons Fork, VA to the confluence of the Potomac River south of Colonial Beach, VA. The total area of the watershed is approximately 28.5 square miles. See Figure 1 for a map of the watershed including monitoring stations.

Figure 1. The Mattox Creek and tributaries watershed map and associated monitoring stations.



2.2.2. Geology, Climate, Land Use

Geology and Soils

The impaired segments of the Mattox Creek and tributaries are predominately within the Atlantic Coastal Plain physiographic region, though the headwaters of some tributaries are located within the lower Piedmont physiographic province. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces.

The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.dcr.virginia.gov/natural_heritage/documents/overviewPhysiography_vegetation.pdf).

Soils for the Mattox Creek watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (<http://soils.usda.gov/technical/classification/osd/index.html>). Figure 2 shows the location of these general soil types in the watershed.

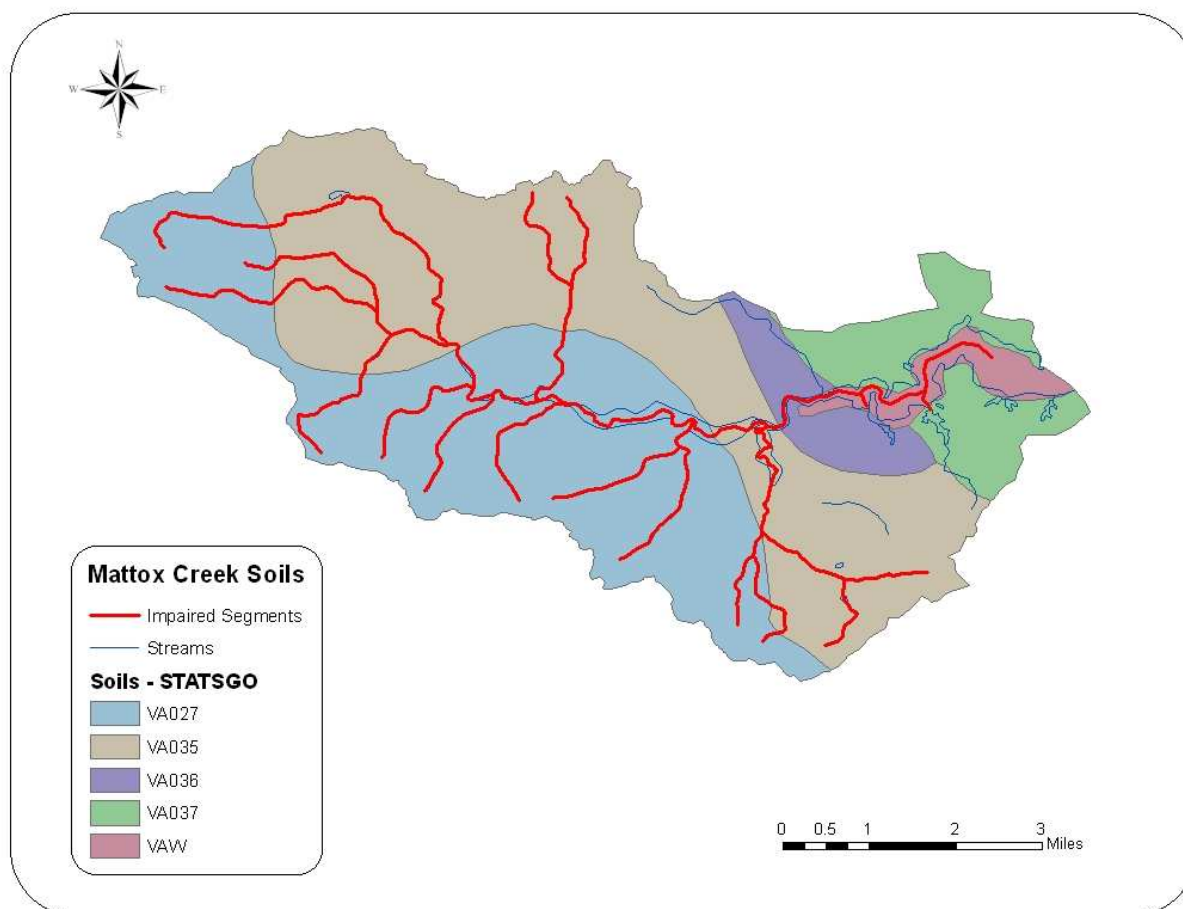
Soils of the **Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027)** series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

The soils of the **Craven-Mattaponi-Lenoir-Coxville (VA035)** series are very deep in which the drainage ranges from somewhat poor to well drained and the permeability is typically slow to moderately slow. The soils formed in flats or depressions from the lower to upper Coastal Plain and Piedmont Physiographic Provinces of the Atlantic Coast, in which the parent materials consists of fluvial and marine sediments.

Soils of the **Tetotum-Nansemond-State-Emporia-Draxton-Nimmo-Bladen (VA036)** series are very deep and range from well drained to poorly drained. Permeability ranges from moderately rapid and/or rapid to moderately slow or slow. This soil series was formed in sandy or loamy fluvial and marine sediments on Coastal Plain uplands and stream terraces.

Soils of the **Bibb and Levy-Bohicket-Lumbee-Nansemond-Rumford-Tetotum-State-Suffolk (VA037)** Series are very deep to deep, and vary from well drained to very poorly drained. They range in slope from 0 – 15 percent. Their water capacity varies from low to high. This soils series was formed in sandy to loamy to mucky clay alluvial and marine sediments on the upper Coastal Plain and stream terraces.

Figure 2. Soil Characteristics of the Mattox Creek Watershed.



Climate

The climate summary for the Mattox Creek comes from a weather station located in Colonial Beach, VA (441913) with a period of record from 1963 to 2002. The average annual maximum and minimum temperatures (°F) at the weather station are 69.6 and 47.4 and the annual rainfall (inches) is 41.18 (Table 1) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 1. Climate summary for Colonial Beach, Virginia (441913).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	47.2	50.9	58.6	69.4	78.5	86.2	90.4	88.4	82.6	71.1	61.0	41.0	69.6
Average Min. Temperature (F)	27.1	28.9	35.2	44.8	54.8	63.8	68.5	66.6	61.0	47.8	39.7	31.0	47.4
Average Total Precipitation (in.)	3.05	2.85	3.87	3.06	4.11	3.46	4.55	3.46	3.45	3.10	2.86	3.37	41.18

Land Use

The Mattox Creek and tributaries watershed extends approximately 7.5 miles from Weedons Fork to south of Colonial Beach VA, and is 2 - 4 miles wide. The watershed is approximately 18263 acres (28.5 mi²) in size and is predominately forested (56.8 percent). Agriculture comprises 28.5 percent of the watershed, with 9.0 percent cropland and 19.5 percent pasture/hayland. Urban areas compose approximately 3.2 percent of the

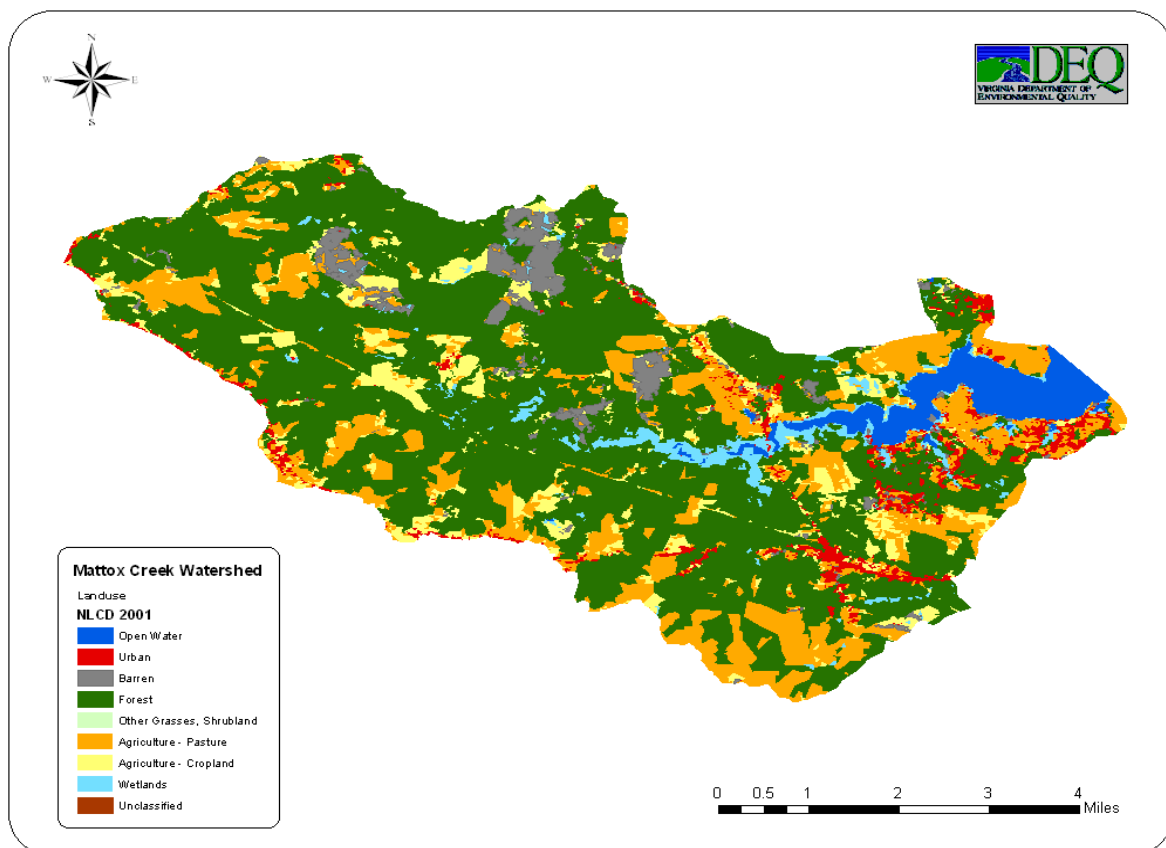
land base. The remaining 4.2 percent of the watershed is comprised of barren areas, and 7.4 percent wetlands and open water. Land use is described in Table 2.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated near the mouth, especially on the south bank, and along Rts. 3 and 205, and wetlands / water land use is concentrated along the mainstem in the center and downstream portions to the mouth.

Table 2. Land Use in the Mattox Creek and Tributaries Watershed

	<u>Acres</u>	<u>Square Miles</u>	<u>Percentage</u>
Open Water	743.2	1.2	4.1%
Urban	579.1	0.9	3.2%
Barren	762.0	1.2	4.2%
Forest	10365.1	16.2	56.8%
Other Grasses, Shrubland	0.0	0.0	0.0%
Agriculture - Pasture	3561.1	5.6	19.5%
Agriculture - Cropland	1646.0	2.6	9.0%
Wetlands	606.8	0.9	3.3%
Total	18263.2	28.5	100%

Figure 3. Land Use in the Mattox Creek and Tributaries Watershed



3. Description of Water Quality Problem/Impairment

The mainstem of Mattox Creek was listed as impaired on Virginia's 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004, 2006, and 2008 305(b) / 303(d) Integrated Reports (VADEQ, 2002, 2004, 2006, and 2008) due to violations of the State's water quality standard for pH. Mattox Creek and tributaries were then listed due to violations of the State's water quality standard for DO in the 2006 and 2008

305(b) / 303(d) Integrated Reports. This report evaluates both the pH and DO impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ monitored 2 stations on non-tidal Mattox Creek and 3 stations on tributaries (Figure 1) with dates ranging from April 1996 through July 2006. Of the 152 total pH data points recorded, 106 violated water quality standards for pH (70%), and 12 of 152 DO data points violated the water quality standards for DO concentration, however 5 of 23 were concentrated at one station 1AMAO010.27 (22%) and in the 2008 assessment 4 of 35 DO values at the original listing station 1AMAO007.46 (11%) violated the water quality standard. The pH minimum and maximum values ranged from 4.97 to 6.95 mg/L, and DO values ranged from 1.37 to 13.89 mg/l. The results are summarized in Table 3.

Table 3. pH and DO data collected by DEQ from 5 stations on Mattox Creek and tributaries.

Station	Sample Period	Number of Samples		SU		mg/l		Number of Violations	
		pH	DO	Average pH	Min-Max pH	Average DO	Min-Max DO	pH	DO
1AMAO007.46	4/17/1996 to 12/7/2006	62	62	5.81	4.97-6.95	8.02	1.37-13.89	43	4
1AMAO010.27	4/23/1996 to 4/15/2005	23	23	5.52	4.99-6.22	7.63	1.46-13.73	20	5
1AKIG000.62	4/23/1996 to 4/15/2005	23	23	5.75	5.28-6.44	8.29	3.36-12.89	17	2
1ACOW000.38	7/21/2003-4/15/2005	22	22	5.73	5.22-6.40	8.93	3.91-12.42	17	1
1AXXFF001.61	7/21/2003-4/15/2005	22	22	6.03	5.12-6.82	8.78	3.76-12.48	8	1

Time series graphs of all pH and DO data collected at the original listing station, Mattox Creek at Rt. 627, 1AMAO007.46, shows the pH ranging from 4.97 to 6.95 (Figure 4) and DO ranged from 1.37 mg/l to 13.89 mg/l (Figure 5). The horizontal line at the pH = 6.0 mark represents the minimum water quality standard. The data points below the pH = 6.0 line illustrate violations of the water quality standard in Figure 4. The horizontal line at the DO = 4.0 mark represents the minimum water quality standard. The data points below the DO = 4.0 line illustrate violations of the water quality standard in Figure 5.

Figure 4. Time series of pH at Mattox Creek at Rt. 627, (station 1AMAO007.46).

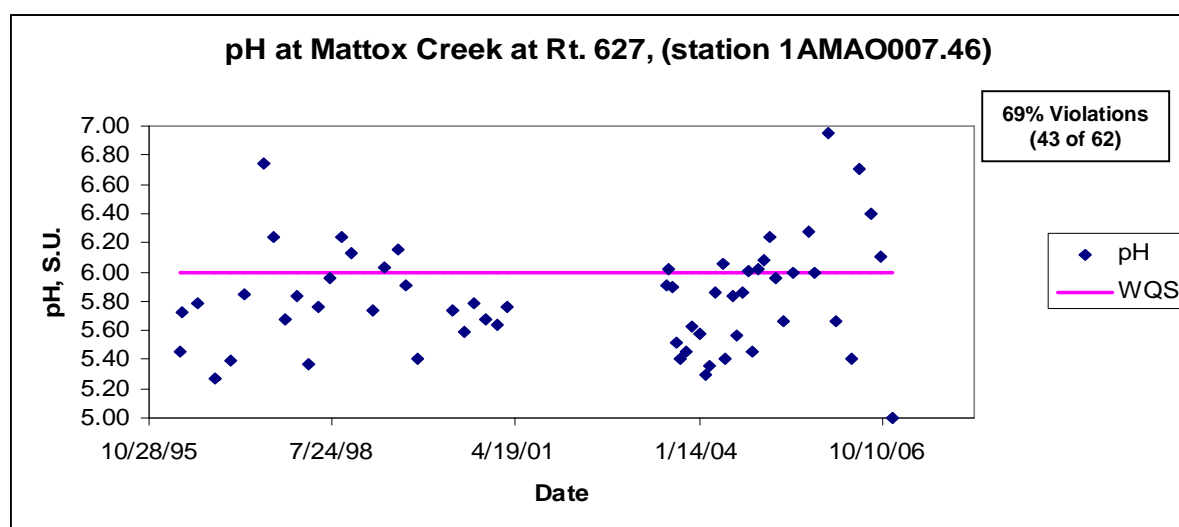
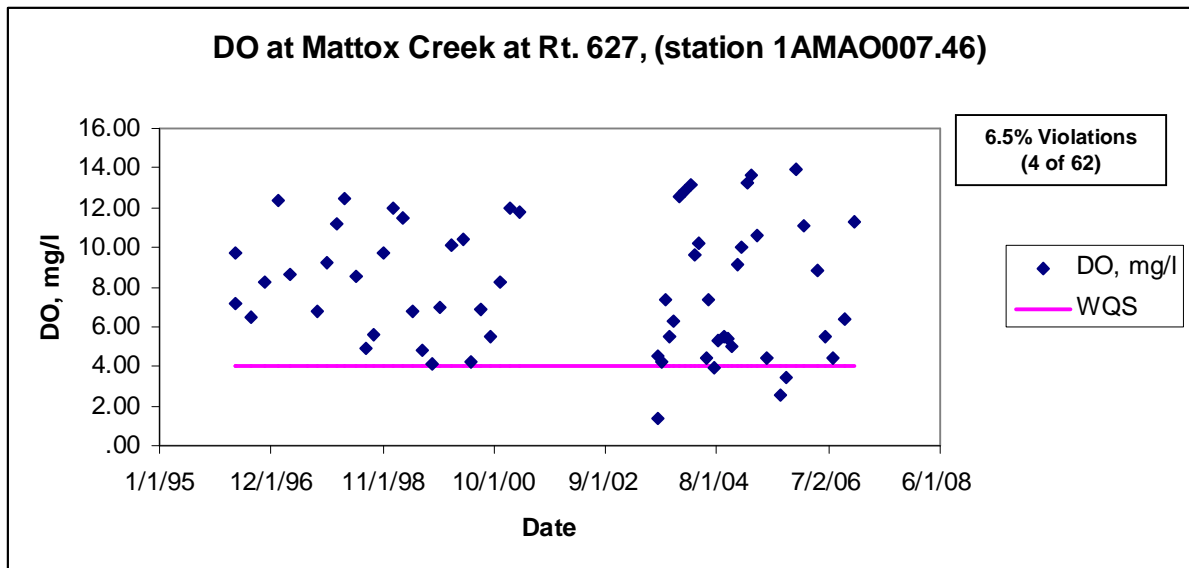


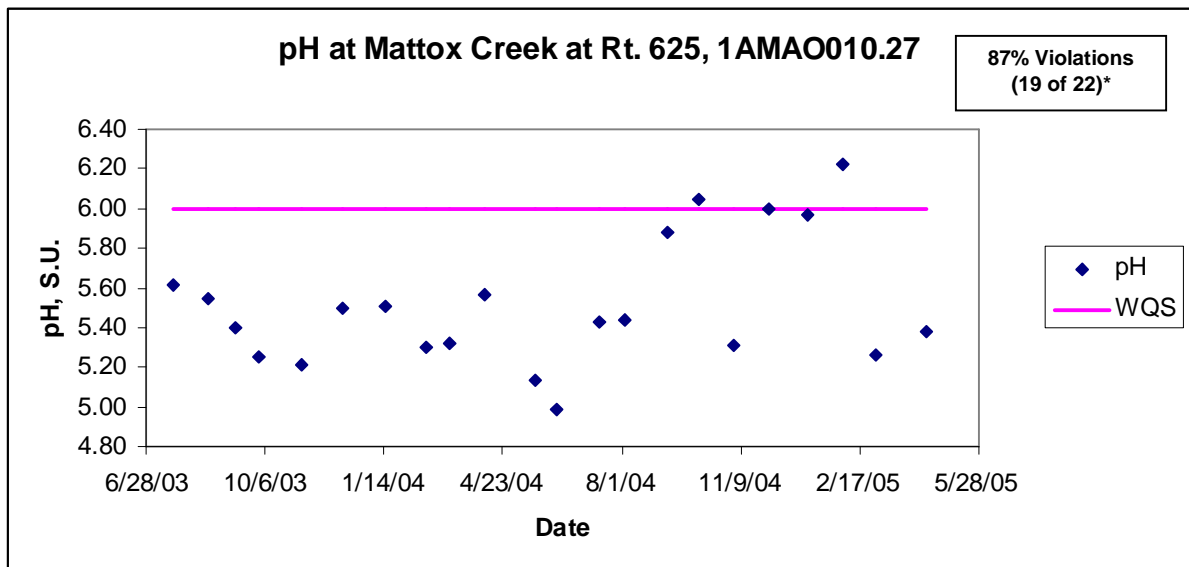
Figure 5. Time series of DO at Mattox Creek at Rt. 627, (station 1AMAO007.46).



3.1 Associated pH and DO of Mattox Creek and Tributaries

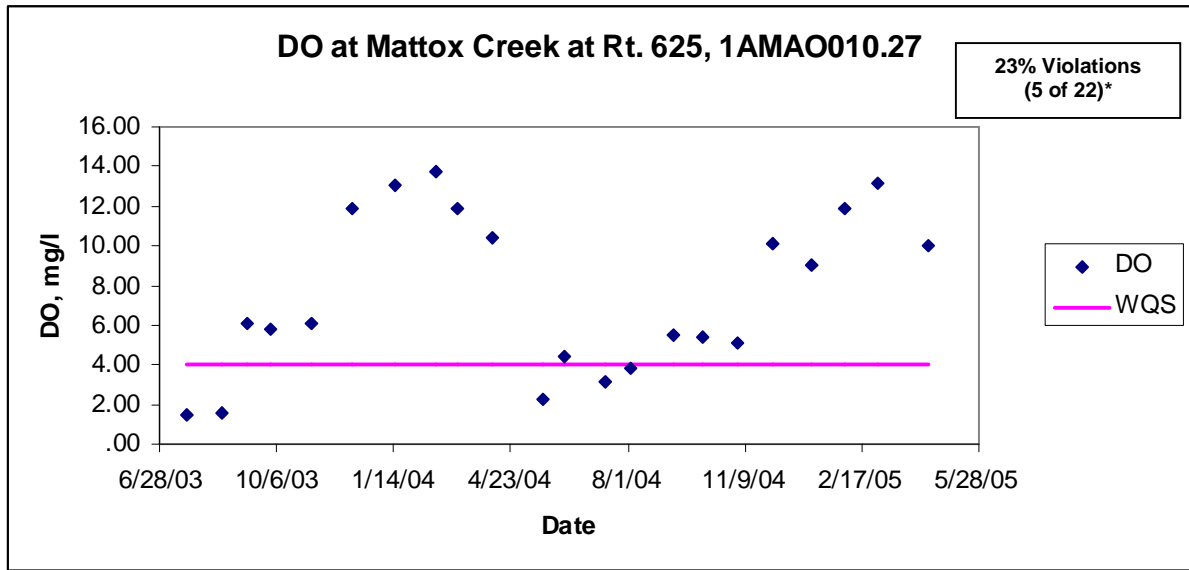
DEQ also monitored and collected pH and DO data at one station from upper mainstem Mattox Creek and 3 tributaries for the assessment of low pH and DO due to the natural conditions. Associated stations with pH and DO data are presented in Figures 6-13 below.

Figure 6. pH at Mattox Creek at Rt. 625, 1AMAO010.27.



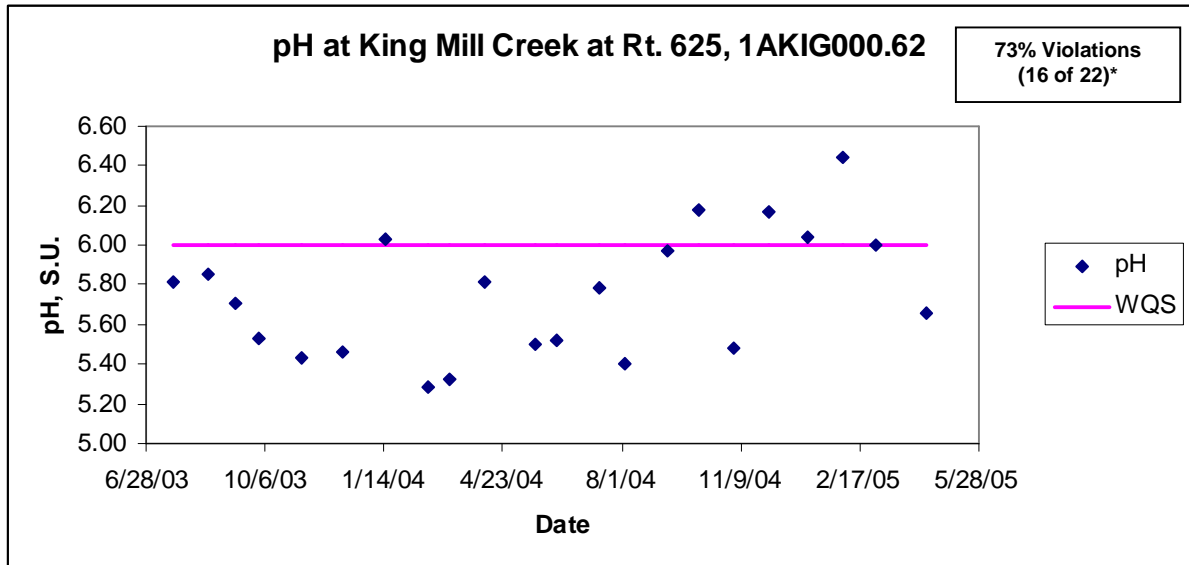
* - One violation from 1996, 6 years earlier, not charted.

Figure 7. DO at Mattox Creek at Rt. 625, 1AMAO010.27.



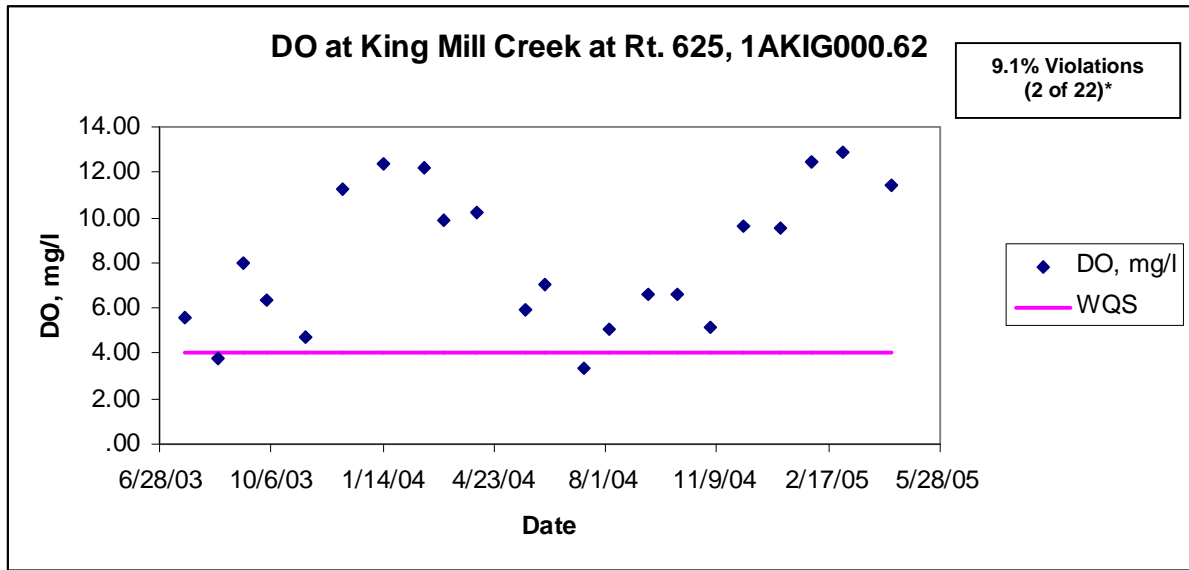
* - One non-violation from 1996, 6 years earlier, not charted.

Figure 8. pH at King Mill Creek at Rt. 625, 1AKIG000.62.



* - One violation from 1996, 6 years earlier, not charted.

Figure 9. DO at King Mill Creek at Rt. 625, 1AKIG000.62.



* - One non-violation from 1996, 6 years earlier, not charted.

Figure 10. pH at Cow Swamp at Rt 628, 1ACOW000.38.

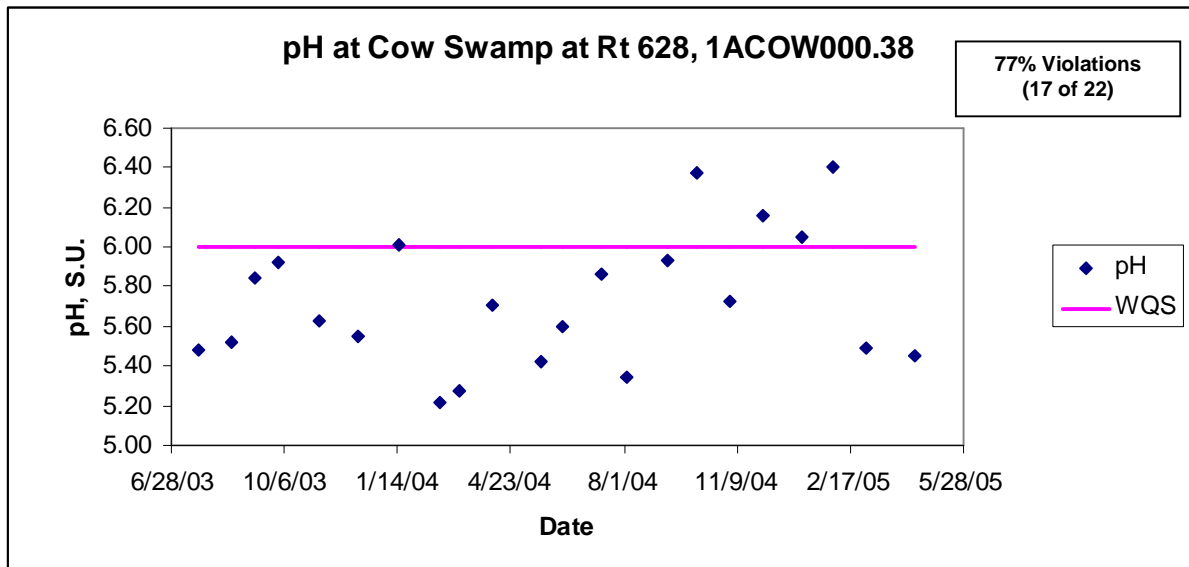


Figure 11. DO at Cow Swamp at Rt 628, 1ACOW000.38.

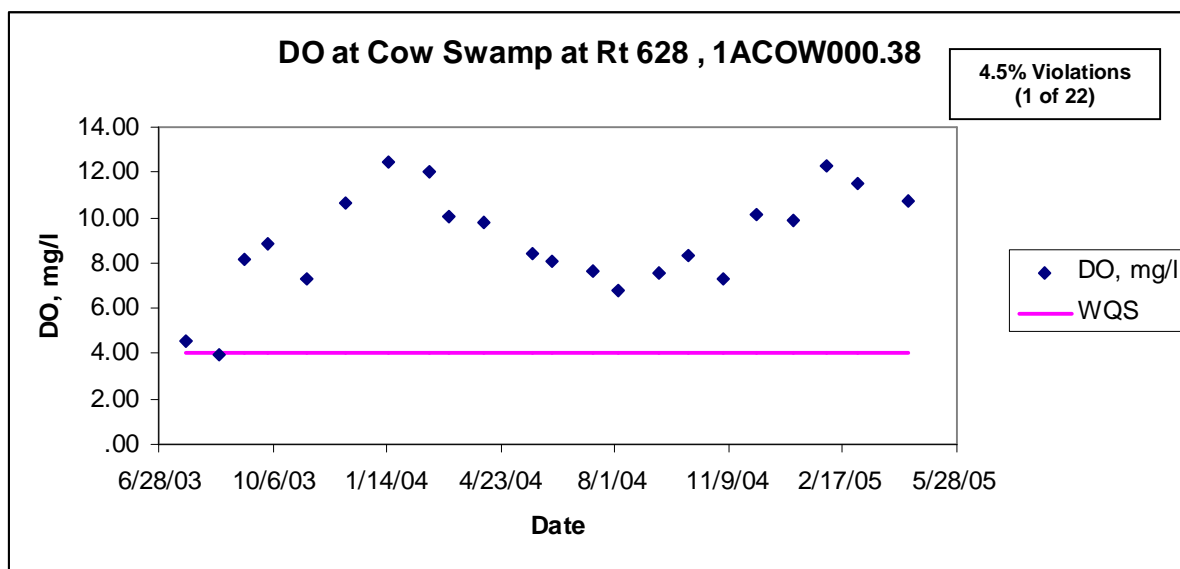


Figure 12. pH at UT to Mattox Cr at Rt. 3, 1AXFF001.61.

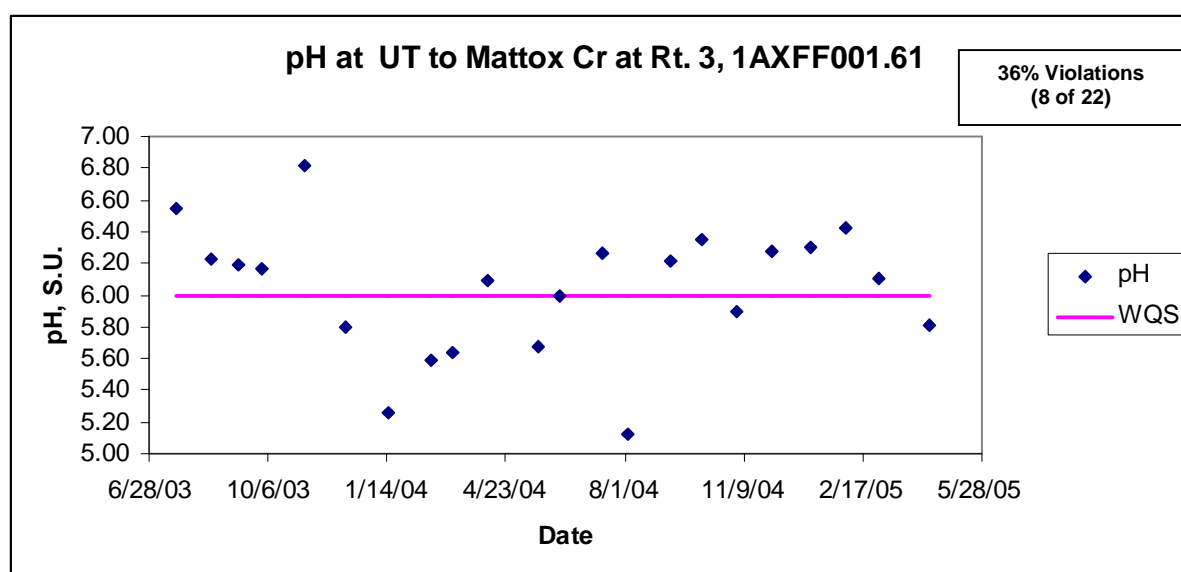
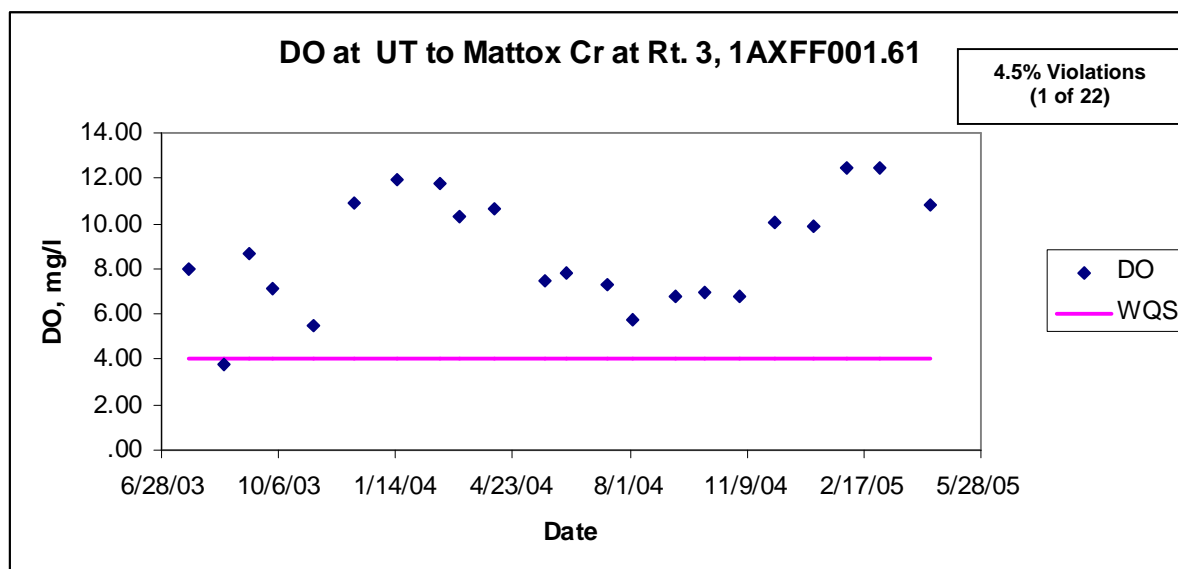


Figure 13. DO at UT to Mattox Cr at Rt. 3, 1AXFF001.61.



All stations monitored on Mattox Creek and tributaries exceeded the water quality standards for pH in more than 10 percent of visits. Only Mattox Creek at Rt. 625 in the upstream mainstem exceeded the DO standard in more than 10 percent of visits

4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term “water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.).”

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), “all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish).”

As stated above, Mattox Creek must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO and pH in the Mattox Creek watershed are an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards		
Parameter	Minimum, mg/l	Maximum, mg/l
pH	6.0	9.0

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

- Step 1. Determine slope and appearance.
- Step 2. Determine nutrient levels.
- Step 3. Determine degree of seasonal fluctuation (for DO only).
- Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (e.g., decomposition and respiration) and oxygen-restoring processes (e.g., aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background
❖ average (= assessment period mean) nitrate less than 0.6 mg/L
❖ average total nitrogen (TN) less than 1.0 mg/L, and
❖ average total phosphorus (TP) are less than 0.1 mg/L AND
For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

- THEN determine as impaired due to natural condition
- assess as category 4C in next assessment
 - initiate WQS reclassification to Class VII Swamp Water
 - get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flow for the Mattox Creek and tributaries may be estimated by a drainage area ratio of the Mattox Creek watershed (28.5 mi²) with the 7Q10 flow at the long-term continuous gauging station Piscataway Creek near Tappahannock, VA, (USGS: 01669000), with a drainage area of 28.0 mi² and a 7Q10 of 0.50 cfs. Thus the 7Q10 of Mattox Creek is estimated at 0.51 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

No Mattox Creek and tributaries pH or DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The slope of Mattox Creek and the three largest tributaries was determined. The low slope for these streams ranged from 0.19% to 0.42% (Table 5), which is less than the defined low slope criteria of 0.50%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts. A second unnamed tributary (UT) to Mattox Creek was included in the report because the slope meets the criteria for swampwater and it contains areas of forested land with swamps and heavy tree canopy throughout the watershed like the other tributaries in the study. DEQ did not have a monitoring station on this UT because it lacks public access.

Table 5. Calculated percent slopes for Mattox Creek and Tributaries.

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Mattox Creek	0.19	50' at RM 11.08	10' at RM 7.08
UT to Mattox Creek (XFF001.61)	0.23	20' at RM 2.03	5' at RM 0.81
UT to Mattox Creek unmonitored, no access	0.22	30' at RM 1.69	10' at RM 0.00
Kings Mill Creek	0.38	60' at RM 1.81+ 0.16 mi on Mattox Cr	20' at MAO RM 8.53

Cow Swamp

0.42

50' at COW RM 0.50

20' at MAO RM 8.53

Visual inspections of Mattox Creek and tributaries revealed swampy areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs. (Figures 14-16).

Figure 14. Mattox Creek, Rt. 627, Upstream.



Figure 15. Mattox Creek at Rt. 625, Upstream.



Figure 16. Kings Mill Creek, Rt. 625, Upstream.

5.3 Instream Nutrients

The VADEQ collected nutrient data from the original listing station 1AMAO007.46 stations, four located on Mattox Creek and three on tributaries (April 1996 to Dec 2006, Table 6). Data points below the limit of detection were averaged using half the detection limit. The average nutrient concentrations are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO₃ + NO₂) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Table 6. Instream Nutrients of Mattox Creek at Rt. 627, 1AMAO007.46.

Parameter	Average Conc.	Number
Total Phosphorus	0.069 mg/l	(n=37)
Orthophosphorus	0.044 mg/l	(n=28)
Total Kjeldahl Nitrogen	0.620 mg/l	(n=27)
Ammonia as N	0.056 mg/l	(n=38)
Nitrate as N	0.155 mg/l	(n=28)
Nitrite as N	0.010 mg/l	(n=28)
TN (TKN + NO₃ + NO₂)	0.780 mg/l	(n=37)
Nitrite + Nitrate, Total as N	0.206 mg/l	(n=10)

5.4 Natural Seasonal DO Fluctuation

The historical data collected at the Mattox Creek original listing station 1AMAO007.46 and the only station impaired for DO, 1AMAO010.27, were graphed to demonstrate the natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figures 17 and 18.

Figure 17. Seasonal DO Variation at Mattox Creek at Rt. 627, April 1996 through Dec 2006.

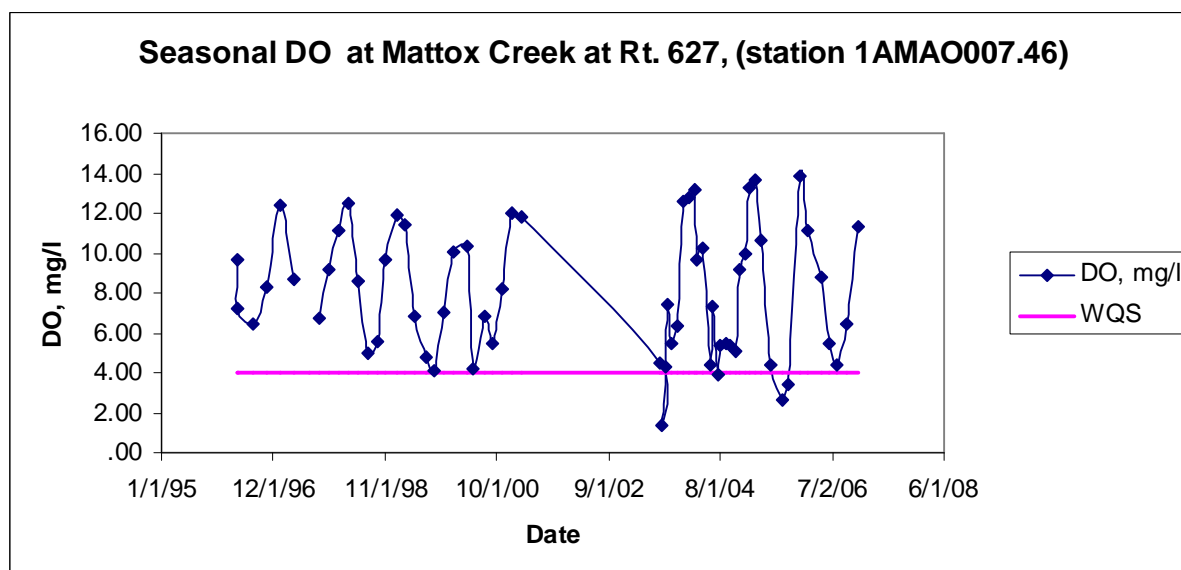
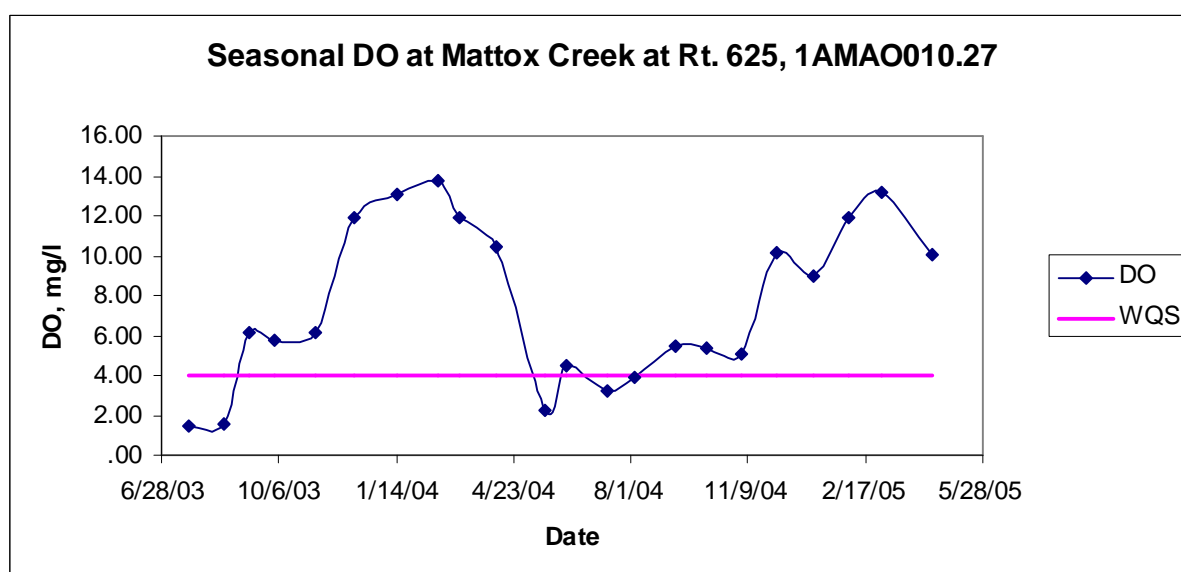


Figure 18. Seasonal DO Variation at Mattox Creek at Rt. 625, July 2003 through April 2005.



5.5 Impact from Point Source Dischargers and Land Use

There are 4 active permitted (1 VPDES; 1 VAG; 1 VAR; 1 VPA) Point Source facilities in the Mattox Creek and tributaries non-tidal watersheds (A31R). The VPDES permittee has a design flow, pH, DO and CBOD5 permit limits, which are shown in Table 7 along with permit exceedances. The facility exceeded its design flow 18 percent of the time with a maximum flow of 0.014 MGD (**0.16 gallons/sec**), however there were no pH permit exceedances, five DO exceedances with a minimum of 4.3 mg/l and 10 CBOD5 exceedances with the maximum of 35 mg/l. Walker Sand & Stone Westmoreland Pit (VAG840081) is a Non-metallic mineral mining permit and only has a pH limit, which it has not exceeded in 18 quarters. Shiloh Baptist Church is an

industrial stormwater permit without limits for DO or pH. Northern Neck Farmers Market is a no discharge permit without DO or pH limits. These facilities are not expected to significantly impact DO or pH.

Table 7. Permitted dischargers with design flows and permit limits located within the Mattox Creek tributaries watersheds.

Facility	Permit	Design Flow (MGD)	pH	DO (mg/L)	CBOD5 (mg/L)	TKN (mg/L)	Receiving Stream
Washington District Elementary School “ “	VA0082058	0.006	6-9	6.9	15	4.5	UT to Mattox Creek at 1AXFF001.63
	# Exceeded/ Tot. months	21/115	0/115	5/115	10/115	6/115	
	Max or min as appropriate	0.014	7.0 – 8.9	4.3	35	7.5	
Walker Sand & Stone Westmoreland Pit “	VAG840081	N/A	6-9	N/A	N/A	N/A	UT to Mattox Creek
	# Exceeded/ Tot. quarters, min - max		0/18, 6.5 - 8.4				
Shiloh Baptist Church	VAR103817	N/A	N/A	N/A	N/A	N/A	Kings Mill Creek
Northern Neck Farmers Market	VPA01422	N/A	N/A	N/A	N/A	N/A	UT to Mattox Creek

Urban areas compose approximately 3.2 percent of the land base, almost all of which occurs downstream of the impaired segment in the tidal portion of the watershed. This leaves an insignificant portion of the urban land use in the non-tidal portion of the watershed. Agriculture makes up approximately 28.5 percent of the watershed. The watershed is predominately forested (56.8 percent), with 3.3 percent wetlands and 4.1 percent open water. Land use was not considered to have significantly impacted the swampwater conditions of Mattox Creek and its tributaries.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND

If wetlands or large areas of forested land are present along stream reach AND

If no point sources or point sources with minimal impact on DO AND

If nutrients are < typical background

❖ average (= assessment period mean) nitrate less than 0.6 mg/L

❖ average total nitrogen (TN) less than 1.0 mg/L, and

❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition

→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water

→ get credit under consent decree

No Mattox Creek and tributaries pH or DO water quality data, standard violations or non-violations were obtained at flows below 7Q10, therefore no data were removed.

The slopes were determined for Mattox Creek and 4 tributaries. The low slope for these streams ranged from 0.19% to 0.42%, which was considered very low to low slope. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand, lower DO, result in production of weak organic acids, and lower pH as they decay. These are not considered anthropogenic impacts.

Mattox Creek and its tributaries exhibit low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

The Mattox Creek tributaries exhibit natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are 4 active permitted (1 VPDES; 1 VAG; 1 VAR; 1 VPA) Point Source facilities in the Mattox Creek and tributaries non-tidal watersheds (A31R). The VPDES permittee has a design flow, pH, DO and CBOD5 permit limits, which are shown in Table 7 along with permit exceedances. The facility exceeded its design flow 18 percent of the time with a maximum flow of 0.014 MGD (**0.16 gallons/sec**), however there were no pH permit exceedances, five DO exceedances with a minimum of 4.3 mg/l and 10 CBOD5 exceedances with the maximum of 35 mg/l. Walker Sand & Stone Westmoreland Pit (VAG840081) is a Non-metallic mineral mining permit and only has a pH limit, which it has not exceeded in 18 quarters. Shiloh Baptist Church is an industrial stormwater permit without limits for DO or pH. Northern Neck Farmers Market is a no discharge permit without DO or pH limits. These facilities are not expected to significantly impact DO or pH.

Urban areas compose approximately 3.2 percent of the land base, almost all of which occurs downstream of the impaired segment in the tidal portion of the watershed. This leaves an insignificant portion of the urban land use in the non-tidal portion of the watershed. Agriculture makes up approximately 28.5 percent of the watershed. The watershed is predominately forested (56.8 percent), with 3.3 percent wetlands and 4.1 percent open water. Land use was not considered to have significantly impacted the swampwater conditions of Mattox Creek and its tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Mattox Creek and its tributaries located in waterbody identification codes (WBID, Virginia Hydrologic Unit) A31R, a total of 31.62 rivermiles. If there is a 305(b)/303(d) assessment prior to the reclassification, Mattox Creek and these tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Mattox Creek tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

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